Manure Composting Manual

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AGRICULTURE, FOOD AND
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Manure Composting Manual

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Chapter 1. Introduction

Producers and researchers are exploring many ways to address environmental sustainability and nuisance problems while adding value and improving transportability of manure to offset the costs of management practices. Manure management includes feed management, collection, transport, storage, handling, treatment, disposal and utilization of manure. This handbook will provide an introduction to agricultural composting and provide additional sources of information for those interested.

Composting is the biological decomposition and stabilization of organic material. The process produces heat that, in turn, produces a final product that is stable, free of pathogens and viable plant seeds, and can be beneficially applied to the land. As the product stabilizes, odours are reduced and pathogens eliminated. When composting high moisture materials, bulking materials are necessary for reducing moisture content and maintaining the integrity of the pile. Ideally, composting will enhance the usefulness of organic by-products as fertilizers, privately and commercially.

Composting is receiving increased attention as an alternative manure management practice due to increased pressures from society to reduce the impact on the environment. The producer may see alternative benefits to the reduction in volume of manure due to composting. Land base required to apply manure compost may stay the same but the producer can economically haul compost further than manure.

Table 1. Benefits and disadvantage of manure compost

Benefits	Disadvantages
• Reduces mass and volume - lower hauling costs • Reduces odour • Pathogens are destroyed • Kills weed seeds • Improves transportability • Soil conditioner • Improves nutrient qualities - the nutrients from compost are released slowly and steadily • Decreases pollutants - stabilizes the volatile nitrogen into large protein particles, reducing losses • Land application when convenient • Saleable product • Increases water retention of soil	• Loss of ammonia (N) • Time and labour involved • Cost of equipment (initial and operating) • Land required for composting • Marketing required for sale

Chapter 2. The Composting Process

Under controlled conditions, composting is accomplished in two main stages: an active stage and a curing stage (**Figure 1**). In the active composting stage, microorganisms consume oxygen (O_2) while feeding on organic matter in manure and produce heat, carbon dioxide (CO_2) and water vapour. During this stage, most of the degradable organic matter is decomposed. A management plan is needed to maintain proper temperature, oxygen and moisture for the organisms. Testing temperature, moisture content, and oxygen levels can help make decisions on composting activities, such as turning, aerating, or adding moisture. These tests can be performed quite simply on site giving quick feedback - from minutes for temperature or oxygen to overnight for moisture content. In the curing phase, microbial activity slows down and as the process nears completion, the material approaches ambient air temperature. Finished compost takes on many of the characteristics of humus, the organic fraction of soil. The material will have been reduced in volume by 20 to 60%, the moisture content by 40% and the weight by up to 50%. One of the key challenges in composting is to retain as much nitrogen as possible. Composting may contribute to the greenhouse effect because carbon dioxide (CO_2), methane (NH_4) and nitrous oxide (NO_2) will be emitted to the atmosphere during composting.

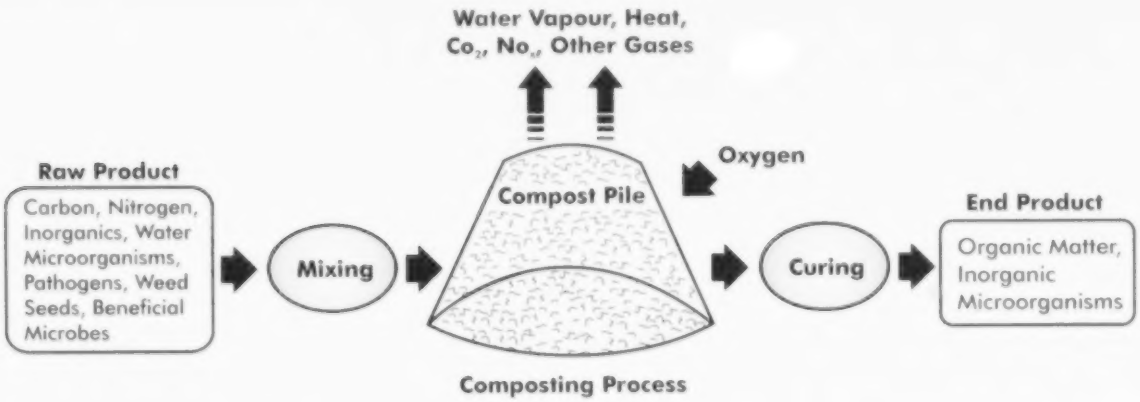

Figure 1. Material flow for the conventional composting process.

Factors Affecting the Composting Process

Controlling the process factors can accelerate the natural composting process. Each of these factors has the potential to significantly affect the composting process. Some of the important factors in the composting process are shown in **Table 2** with their acceptable ranges.

Table 2. Factors affecting the composting process and acceptable ranges

Factor	Acceptable Range
Temperature	54 - 60°C
Carbon to Nitrogen ratio (C:N)	25:1 - 30:1
Aeration, percent oxygen	> 5%
Moisture content	50 - 60%
Porosity	N/A
pH	6.5 - 7.5

Temperature

Temperature is a very good indicator of the process occurring within the composting material. The temperature increases due to the microbial activity and is noticeable within a few hours of forming a pile as easily degradable compounds are consumed. The temperature usually increases rapidly to 50 - 60°C (122 - 140°F) where it is maintained for several weeks. This is called the active composting stage. Biochemical reaction rates approximately double with each 10°C (50°F) increase in temperature, yet higher temperatures will increase ammonia loss during the composting process. The temperature gradually drops to 40°C (104°F) as the active composting slows down and the curing stage begins. Eventually, the temperature will become that of the surrounding air.

The highest rates of decomposition occur when temperatures are in the range of 43 - 66°C (110 - 150°F). During the active composting stage, the temperature may start to fall because of a lack of oxygen. Turning the material introduces new oxygen and the active composting stage continues. The temperatures can exceed 70°C (158°F) but many microorganisms begin to die, which stops the active composting stage. Cooling the material by turning helps to keep the temperature from reaching these damaging levels. Heat loss occurs primarily because of water evaporation from the material. If the moisture content falls too low it increases the chance of obtaining damaging high temperatures.

The temperature should be maintained at 55°C (131°F) or higher for a minimum of 14 days to destroy the viability of many pathogens and weed seeds. Remember, the edges of the windrow are cool, therefore they must be turned into the center to kill the weed seeds.

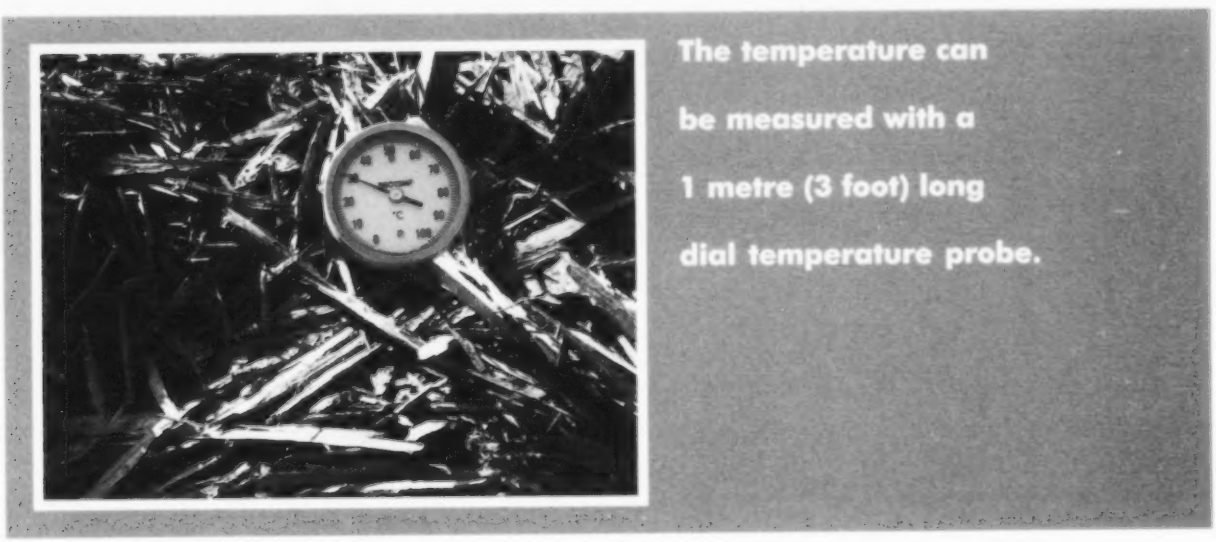

Figure 2. Temperature measurement probe.

Carbon to Nitrogen Ratio

The carbon to nitrogen ratio (C:N) of manure is a very important factor that affects the whole composting process because microbes need 20 to 25 times more carbon than nitrogen to remain active. The ratio should be between 25:1 and 30:1 at the beginning. The microorganisms digest carbon as an energy source and ingest nitrogen for protein and reproduction. Softwood shavings, sawdust and straw are good sources of carbon. Other inexpensive sources of carbon include municipal waste and shredded newsprint or cardboard. Most manures are a good source of nitrogen but may be low in carbon depending on the amount of bedding used. **Table 3**, in this chapter, lists the C:N ratio for materials commonly included in farm compost. The content of materials on your farm can be estimated using the table or a laboratory can perform the analysis.

If the ratio is too high (insufficient nitrogen), the decomposition slows. If the ratio is too low (too much nitrogen), it will likely be lost to the atmosphere in the form of ammonia gas. This can lead to odour problems (refer to the troubleshooting table in the back of the manual for solutions). Most materials available for composting do not fit the ideal ratio so different materials must be blended. Proper blending of carbon and nitrogen helps ensure that composting temperatures will be high enough for the process to work efficiently and ensures other nutrients are available for microbes in adequate supply.

Aeration

The minimum desirable oxygen concentration in the composting material is 5%. Greater than 10% is ideal to avoid anaerobic conditions and high odour potential. Aeration adds fresh air in the center of the composting material. Rapid aerobic decomposition can only occur in the presence of sufficient oxygen. Aeration occurs naturally when air warmed by the compost rises through the material, drawing in fresh air from the surroundings at the base of the windrow. Initial mixing of materials usually introduces enough air to start composting. Porosity and moisture content affect air movement through the composting material. Regular mixing of the material, referred to as turning, enhances aeration in the composting material. Good aeration during composting will encourage complete decomposition of carbon (C) to carbon dioxide (CO_2) rather than releasing carbon as methane (CH_4). Too much aeration, however, can actually reduce the rate of decomposition by cooling the composting material and may cause the release of too much CO_2.

The oxygen concentration can be measured with an oxygen probe. However, temperature provides an adequate indication of the process conditions. If the supply of oxygen is limited, the composting process slows and the temperature begins to fall. In this case the composting materials should be turned.

Moisture Content

Moisture plays an essential role in the metabolism of microorganisms and indirectly in the supply of oxygen. Microorganisms can utilize only those organic molecules that are dissolved in water. Moisture content between 50 and 60% provides adequate moisture without limiting aeration. If the moisture content falls below 40%, bacterial activity will slow down and will cease entirely below 15%. When the moisture content exceeds 60%, nutrients are leached, porosity is reduced, odours are produced (due to anaerobic conditions) and decomposition slows. The squeeze test can be used to check the moisture content. The material is too wet if water can be squeezed out of a handful and too dry if the material doesn't form a ball when squeezed.

Caution: Material in the pile will be very hot, use a shovel to remove material.

If the pile becomes too wet, it should be turned. This allows air to circulate back into it and loosens

the materials for better draining and drying. Adding dry material, such as straw, sawdust or finished compost can also remedy excess moisture problems.

If the material is too dry, water can be added. An effective practice is to turn the material and rewet materials in the process. Shaping the pile can assist in shedding excess water from the pile. A windrow cover can be used to keep unwanted moisture from the elements out of the windrow and conserve moisture within the windrow. Optimum moisture content of raw materials should be between 50 and 60% (wet basis), depending on particle size, available nutrients and physical characteristics.

Porosity

Porosity refers to the spaces between particles in the compost material. These spaces are partially filled with air that can supply oxygen to the organisms and provide a path for air circulation. As the material becomes water saturated, the space available for air decreases, thus slowing the composting process.

Compacting the composting material reduces the porosity. Excessive shredding can also impede air circulation by creating smaller particles and pores. Turning fluffs up the material and increases its porosity. Adding coarse materials such as straw or woodchips can increase the overall porosity, although some coarse materials will be slow to decompose.

pH of Materials

The optimum pH for microorganisms involved in composting lies between 6.5 and 7.5. The pH of most animal manures is approximately 6.8 to 7.4. Composting alone leads to major changes in materials and their pH as decomposition occurs. For example, release of organic acids may, temporarily, lower the pH (increase acidity), and production of ammonia from nitrogenous compounds may raise the pH (increase alkalinity) during early stages of composting. On-site laboratory tests of pH can be used to maintain process control and product quality at a composting site.

Nutrients

Adequate levels of phosphorus (P), potassium (K), carbon (C), nitrogen (N), etc. are important in the composting process and are normally present in farm organic materials such as manure and livestock mortalities. Nutrient loss can occur through volatilization, losses to the atmosphere and leaching. Composting converts the nutrients in manure to stable forms that have a low ability to be lost by volatilization and leaching when applied to the land. However, during the composting process substantial amounts of nitrogen will be lost through ammonia volatilization. The ammonia emissions during composting reduce the fertilizer value of the finished compost. There is no solid data that compares the losses of N by ammonia volatilization during composting and N losses by ammonia volatilization during applying raw manure to soil. Nitrogen losses can also occur from emission of nitrous oxides or nitrogen gas.

Toxic Substances: CAUTION

Some organic materials may contain substances that are toxic to composting bacteria or bacteria required for composting. Heavy metals such as manganese, copper, zinc, nickel, chromium and lead fall into this category and may be immobilized chemically prior to composting. A laboratory can analyze samples of raw materials for toxic substances. Weathered fly ash, after equilibrating with atmospheric CO_2, is called lagoon ash, which has an alkaline pH and provides a good fixing agent to suppress the availability of heavy metals in manure compost.

Material Characteristics

It is important to be familiar with the material used in composting. Make sure to have proper C:N ratios. Materials can be blended together to attain the proper ratio. **Table 3** contains characteristics of common on-farm composting materials. In order to blend materials in suitable proportions several factors must be considered. The necessary formulas and a sample calculation are in **Appendix A**.

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Table 3. Characteristics of common composting materials

Material	Nitrogen (dry weight) (%)	C:N (dry weight)	Moisture Content (%)	Bulk Density @ Moisture Content (kg/m³)
Beef				
- Feedlot with bedding	1.30	-	68	-
Dairy				
- Solid manure handling	1.70	18	-	-
- Liquid slurry	2.40 - 3.60	-	88 - 92	-
- Solids separated from slurry	1.45	-	77	-
Pigs				
- Liquid slurry	0.15 - 5.00	20	93 - 99	1000
- Solids separated from slurry	0.35 - 5.00	-	75 - 80	270 - 860
Poultry				
- Broiler breeder layer	3.60	10	46	470
- Broiler litter	4.70	15	25	330
- Turkey litter	4.20	14	33	380
Horse Manure with Bedding	1.40 - 2.30	22 - 50	59 - 79	725 - 960
- with straw	1.50	27	67	-
- with shavings	0.90	65	72	-
Sheep Manure	1.30 - 3.09	13 - 20	60 - 75	-
Oat Straw	0.60 - 1.10	48 - 98	-	-
Wheat Straw	0.30 - 0.50	100 - 150	-	-
Legume Grass Hay	1.80 - 3.60	15 - 19	10 - 30	-
Straw	0.30 - 1.10	48 - 150	4 - 27	58 - 357
Cardboard	0.10	563	8	154
Leaves	0.50 - 1.30	40 - 80	38	60 - 80
Paper	0.20 - 0.25	127 - 178	18 - 20	-
Sawdust	0.06 - 0.80	200 - 750	19 - 65	350 - 450
Woodwaste (Chips)	0.04 - 0.23	212 - 1313	-	445 - 620

Chapter 3. Composting Methods

As outlined in **Table 4**, some basic composting methods use bins, passive windrows, turned windrows, aerated static piles and in-vessel channels. The proper approach depends on the time to complete composting, the material and volume to be decomposed, space available, the availability of resources (labour, finances, etc.) and the quality of finished product required.

Table 4. Basic composting methods

	Bin	Passive Windrow	Active Windrow	Aerated Static Windrow	In-Vessel Channel
General	Low technology, medium quality.	Low technology, quality problems.	Active systems most common on farms.	Effective for farm and municipal use.	Large-scale systems for commercial applications.
Labour	Medium labour required.	Low labour required.	Increases with aeration frequency and poor planning.	System design and planning important. Monitoring needed.	Requires consistent level of management/ product flow to be cost efficient.
Site	Limited land but requires a composting structure.	Requires large land areas.	Can require large land areas.	Less land required given faster rates and effective pile volumes.	Very limited land due to rapid rates and continuous operations.
Bulking Agent	Flexible.	Less flexible, must be porous.	Flexible.	Less flexible, must be porous.	Flexible.
Active Period	Range: 2 - 6 months	Range: 6 - 24 months	Range: 21 - 40 days	Range: 21 - 40 days	Range: 21 - 35 days
Curing	30+ days	Not applicable.	30+ days	30+ days	30+ days
Size: Height	Dependent on bin design.	1 - 4 metres	1 - 2.8 metres	3 - 4.5 metres	Dependent on bay design.
Size: Width	Variable.	3 - 7 metres	3 - 6 metres	Variable.	Variable.
Size: Length	Variable.	Variable.	Variable.	Variable.	Variable.
Aeration System	Natural convection and mechanical turning.	Natural convection only.	Mechanical turning and natural convection.	Forced positive/negative airflow through pile.	Extensive mechanical turning and aeration.
Process Control	Initial mix or layering and one turning.	Initial mix only.	Initial mix and turning.	Initial mix, aeration, temperature and/or time control.	Initial mix, aeration, temperature and/or time control, and turning.
Odour Factors	Odour can occur, but generally during turning.	Odour from the windrow will occur. The larger the windrow the greater the odours.	From surface area of windrow. Turning can create odours during initial weeks.	Odour can occur, but controls can be used, such as pile insulation and filters on air systems.	Odour can occur. Often due to equipment failure or system design limitations.

Bin Composting

Bin composting is produced by natural aeration and through turning, using a tractor front-end loader. This option is primarily used for composting mortalities, yard waste and smaller amounts of manure. Operation and management of poultry and swine mortality compost systems are available from Alberta Agriculture Food and Rural Development.

Do	**stockpile ingredients, such as sawdust so it is available when needed.**

Passive Windrow Composting

Passive windrow composting is the production of compost in piles or windrows by natural aeration over long periods of time. Attention to details such as the porosity of the initial mix, uniform product mixing and particle size greatly improve the speed of the process and product quality. Generally, material to be composted is collected and promptly piled into windrows, which remain untouched. The materials may be wetted before they are initially formed into windrows but this is not essential. Passive aeration has been successfully used in composting manure from poultry, dairy cattle and sheep.

Covering the windrow with a layer of finished compost will help to prevent moisture loss, reduce odour problems and produce more uniform compost. The center of a windrow will quickly become anaerobic and only by turning can it receive a new supply of oxygen. An unpleasant odour will develop in the anaerobic region and may begin to emanate from the composting material; hence, a large land area is necessary to buffer residents and businesses from the odour. Passive composting is not very conducive to oxygen presence. Since rapid composting can take place only in the presence of oxygen, the compost normally will require three years to stabilize.

Do	**use two windrows - build one while the other is decomposing undisturbed.**

Don't	**make the windrow too big (above six feet high) because this inhibits natural aeration and the material will take longer to compost.**

Active Windrow Composting (Turned)

Active windrow composting is the production of compost in windrows using mechanical aeration by a front-end loader or a specially designed windrow turner. Loaders, although inexpensive compared to turners, have a tendency to compact the composting material, are comparatively inefficient, and can result in longer composting periods and less consistent quality. Turned windrow composting represents a low technology and medium labour approach and produces a uniform product.

The most commonly used windrow turners have a series of heavy tines that are placed along a rotating horizontal drum, which turns, mixes, aerates and reforms the windrow as the machine moves forward. These windrow turners are either self-contained units that straddle the row or are towed by a tractor and powered by a tractor PTO (**Figure 3**). The optimum height and width of the windrows depends on the type of equipment used to turn them.

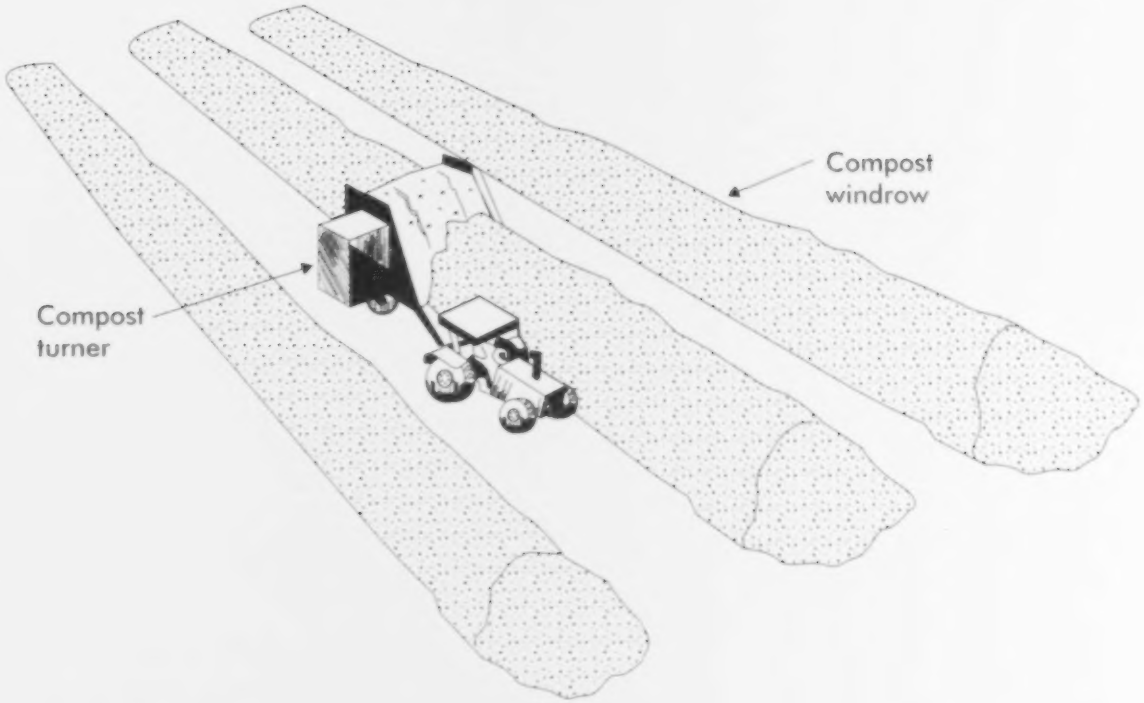

Figure 3. Windrow turning with a pull-type turner.

Windrow composting can produce excellent compost using a variety of diverse materials. Wastes such as manure solids and paunch manure (offal), if in a secure compost area to eliminate scavengers, can be composted with bulking agents such as sawdust, straw and recycled paper products. Windrow composting efficiency and product quality are dependent primarily upon two major factors:

1. The initial compost mix.
2. Management practices.

Do	**measure the temperature within the windrow to determine when to turn the windrow.**

Don't	**forget to check for lack of reheating after turning to signal the end of the active composting stage.**

Aerated Static Pile Composting

Aerated static pile composting is the production of compost in piles or windrows with mechanical aeration and an air source such as perforated plastic pipes, aeration cones or a perforated floor. Aeration is accomplished either by forcing or drawing air through the compost pile. Aeration systems can be relatively simple using electrical motors, fans and ducting, or they can be more sophisticated incorporating various sensors and alarms.

This system of aeration requires electricity at the site and appropriate ventilation fans, ducts and monitoring equipment. The monitoring equipment determines the timing, duration and direction of airflow. The pile should be placed after the floors are first covered with a layer of a bulking agent, such as wood chips or finished compost. The material to be composted is then added and a topping layer of finished compost applied to provide insulation.

A major difficulty with the static pile system is the efficient diffusion of air throughout the entire pile, especially with wastes characterized by a large particle size distribution, high moisture content or a tendency to clump, such as dairy manure. Other problems include the formation of channels in the pile, which allow forced air to short-circuit. This causes excessive drying due to evaporation of moisture near the channels.

Do	**ensure materials chosen to compost have the proper porosity to prevent short-circuiting of air, such as dry wood chips.**

Don't	**assume that the airflow system provides adequate airflow uniformly.**

In-Vessel Composting

In-vessel composting is the production of compost in drums, silos or channels using a high-rate controlled aeration system designed to provide optimal conditions. Aeration of the material is accomplished by:

1. Continuous agitation using aerating machines which operate in concrete bays.
2. Fans providing air flow from ducts built into concrete floors.

The main advantages of the in-vessel system over others are the shortening of the mesophilic (20 - 40°C) and thermophilic (> 40°C) stages, more efficient composting process and a decreased number of pathogens resulting in a safer and more valuable end product. In-vessel composting can maintain a rapid decomposition process year-round regardless of external ambient conditions.
Disadvantages of the enclosed vessel method include high capital and operational costs due to the use of computerized equipment and skilled labour.
In-vessel composters are generally more automated than active or static pile systems and can produce a top quality finished product on a consistent basis.

Do	**investigate the costs associated with building this type of facility.**

Don't	**forget that the materials need to be aerated by turning them.**

For more information on any of the composting methods contact Alberta Agriculture, Food and Rural Development.

Figure 4. In-vessel composting.

Chapter 4. Site Selection for Composting

If the production facility where the compost is to be made falls under the *Agricultural Operation Practices Act* (AOPA), contact the Natural Resources Conservation Board (NRCB) regarding site selection.

There are several factors to consider when choosing a composting site:

Space Requirements

- The site must have sufficient area for the volume of manure to be composted and should have sufficient area for future expansion.
- Consideration should be given to the space required for operation of the equipment at the site.
- Take into account the impact on the farm residence and any neighbouring residences.

Buffer to Sensitive Land Uses

Appropriate separation or buffer distances **(Table 5)** between the composting operation and nearby water resources (surface and groundwater) and neighbouring homes can help to minimize the impact of any odour associated with raw materials, protect the water resources from possible contamination, and also meet the regulations.

Table 5. Distances between composting sites and sensitive areas*

Feature	Minimum Distance Separation
Residential or urban use area	300 m
Property line	10 m
Place where food is served or stored	100 m
Water and drainage course, slough, lakes and dugouts	100 m
Water wells	150 m
Road allowance	30 m

*Source: Alberta Environment. 1996. Code of Practice for Compost Facilities.

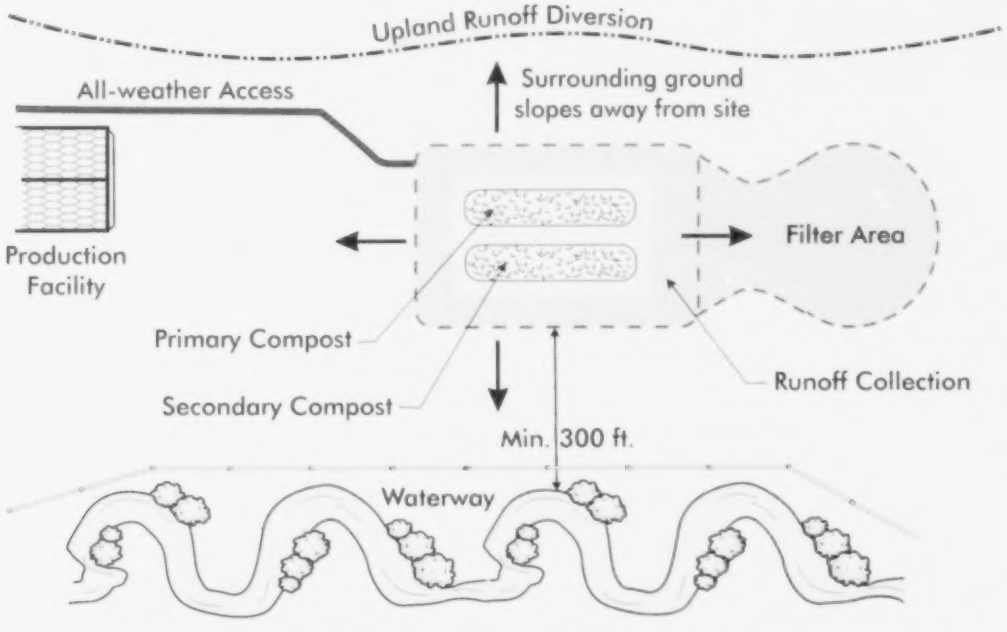

Figure 5. General site layout recommendations for composting facilities.

Site Characteristics

- Choose the location that has compacted soil or an impervious surface to reduce the seepage of the nutrient into the groundwater.
- The site must be sloped between 2 to 4%.
- The site must have a moderate to well drained soil surface.
- The site must be visible and have an easy access to hauling and storage.

Protection of Water Resources

- The site must have a permanent water diversion that works to keep surface runoff away from compost storage areas.
- Placement of manure storage, stacking or composting area should be a safe distance from floodways, wells or springs.

Chapter 5. Compost Regulations

There are both federal and provincial regulations governing compost. Both Alberta Environment and the Natural Resources Conservation Board (NRCB) are responsible for provincial regulations. The NRCB administers a one-window approach for confined feeding operations and for the compliance monitoring and enforcement of province-wide standards under the *Agricultural Operation Practices Act* (AOPA). On-farm manure composting is regulated by AOPA. Guidelines for locating compost facilities are found in Section 3 of the *Standards and Administration Regulation* of AOPA. Prior to setting up a composting facility, contact the NRCB to be advised on how the regulations affect you.

The Canadian Food Inspection Agency (CFIA) *Fertilizer Act* regulates the sale of all compost in Canada. The label for both bagged and bulk sales of compost from any individual must comply with CFIA standards. Contact CFIA with the proposed labels prior to selling compost.

Chapter 6. Compost Uses

Compost has numerous agronomic and horticultural uses. It can be used as a soil amendment, fertilizer supplement, top dressing for pastures and hay crops, mulch for homes and gardens, and a potting mix component. In these examples, the compost increases the water and nutrient retention of the soil, provides a porous medium for roots to grow in, increases the organic matter and decreases the bulk density or penetration resistance.

Troubleshooting

Table 6. Manure composting troubleshooting

Problem	Possible Causes	Solutions
The inside of the windrow is dry	Not enough water	Add water when turning the windrow
Temperature is too high	1. Low to moderate moisture	1. Add more water and continue turning the windrow
	2. The windrow is too big	2. Try to decrease the size of the windrow
Temperature is too low	1. Insufficient aeration	1. Turn the windrow more frequently to increase the airflow
	2. Wet condition of the windrow	2. Add more dry material
	3. Low pH	3. Add lime or wood ash and remix
Ammonia odour	1. High level of N (C:N ratio less than 20:1)	1. Add high carbon material, such as sawdust, woodchips, or straw
	2. High pH	2.Lower pH by adding acidic ingredients (leaves) or avoid adding more alkaline materials such as lime and wood ash
Hydrogen sulphide odour	Windrow material is too wet and its temperature is too low	Add dry bulk material

Questions To Be Addressed Prior To Composting

- ☐ Do you have enough manure on your farm to compost?
- ☐ Do you have a site appropriate for composting?
- ☐ What composting method is best suited for your operation?
- ☐ Do you have access to carbon amendments such as straw, woodchips, etc.?
- ☐ Will compost product be for on-farm use or for export off the farm?
- ☐ If your compost is for off-farm sales, do you have a marketing strategy?
- ☐ Is there a market for compost in your area?

Additional Information

Alberta Agriculture, Food, and Rural Development

AgTech Centre
3000 College Drive
Lethbridge, Alberta
T1K 1L6
(403) 329-1212

Environmental Practices Unit
J. G. O'Donoghue Building
Rm. 306, 7000 - 113 Street
Edmonton, Alberta
T6H 5T6
(780) 422-4844

Olds College

4500 - 50 St., Olds, Alberta T4H 1R6
or http://www3.gov.ab.ca/env/waste/aow/orgcomp/

Alberta Environment

Peace River	(780) 624-6502
Edmonton	(780) 427-9563
Stony Plain	(780) 963-6131
Red Deer	(403) 340-7721
Calgary	(403) 297-7883
Lethbridge	(403) 381-5995

or http://www.qp.gov.ab.ca/documents/codes/COMPOST.CFM

Natural Resources Conservation Board (NRCB)

Barrhead	(780) 674-8303
Calgary	(403) 662-3990
Edmonton	(780) 422-1977
Fairview	(780) 835-7111
Lethbridge	(403) 381-5166
Red Deer	(403) 340-5241

or http://www.nrcb.gov.ab.ca/web/about/contacts.cfm

Canadian Food Inspection Agency (CFIA)

Head Office	Alberta North	Alberta South
59 Camelot Dr.	Rm. 205, 7000 - 113 St.	3650 - 36 St. NW
Ottaw, Ontario	Edmonton, Alberta	Calgary, Alberta
K1A 0Y9	T6H 5T6	T2L 2L1
1-800-442-2342	(780) 495-3333	(403) 299-7660

Alberta Agriculture, Food and Rural Development
Agtech Centre, Technical Services Division
Phone: (403) 329-1212
Windrow Turner Evaluations Report
Poultry and Swine Mortality Composting Handbooks

AAFRD Publication Office
Phone: 1-800-292-5797 or www.agric.gov.ab.ca/publications

CCME Guidelines for Compost Quality (CCME-106E)
Phone: (204) 945-4664
or www.compost.org/compostqualitydoc.pdf
www.compost.org/standard.html

References

Alberta Environment. 1996. Code of Practice for Compost Facilities.

B.C. Agricultural Composting Handbook
Second Edition, 2nd printing, September, 1998.
Ministry of Agriculture and Food.

Further Reading

Haug, Roger T. The Practical Handbook of Compost Engineering. London: Lewis Publishers, 1993.

Rynk, Robert, On-Farm Composting: The Process and Methods, Cooperative Extension University of Massachusetts, Amherst Ma, 1992.

Saskatchewan Agriculture, Food, and Rural Revitalization
http://www.agr.gov.sk.ca/docs/crops/integrated_pest_management/Soil_fertility_fertilizers/CompostManure02.asp?firstPick=Livestock&secondpick=Pork&thirdpick=Manure%20Management

Appendix A. Blending Sample Calculation

(B.C. Agricultural Composting Handbook, Second Edition, 2nd printing, September, 1998, Ministry of Agriculture and Food.)

Appendix A_1

Symbols

a	=	total weight of ingredient a
b	=	total weight of ingredient b
c	=	total weight of ingredient c
M	=	desired mix moisture content
Ma, Mb, Mc…	=	moisture content of ingredients a, b, c
%Ca, %Cb, %Cc…	=	% carbon of ingredients a, b, c… (on dry weight basis)
%Na, %Nb, %Nc…	=	% nitrogen of ingredients a, b, c,… (on dry weight basis)
R	=	desired C:N ratio of mix
Ra, Rb	=	C:N ratio of ingredients a, b, c

Appendix A_2

Formulas for Only Two Ingredients

Required amount of ingredient a per kg b

To obtain desired C:N raio:

$$a = \frac{\%\,Nb}{\%\,Na} \times \frac{(R-Rb)}{(Ra-R)} \times \frac{(1-Mb)}{(1-Ma)}$$

To obtain desired moisture content:

$$a = \frac{Mb-M}{M-Ma}$$

Appendix A_3

Formulas for a Mix of Materials

$$\text{C:N ratio} = \frac{\text{weight of C in ingredient a + weight of C in b + weight of C in c +…}}{\text{weight of N in a + weight of N in b + weight of N in c +…}}$$

$$= \frac{[\%Ca \times a \times (1-Ma)] + [\%Cb \times b \times (1-Mb)] + [\%Cc \times c \times (1-Mc)]}{[\%Na \times a \times (1-Ma)] + [\%Nb \times b \times (1-Mb)] + [\%Nc \times c \times (1-Mc)]}$$

$$\text{Moisture content} = \frac{\text{weight of water in ingredient a + weight of water in b + weight in water in c + ...}}{\text{total weight of all ingredients}}$$

$$= \frac{(a \times Ma) + (b \times Mb) + (c \times Mc) \ldots}{a + b + c + \ldots 0}$$

Example

Assume a broiler breeder farm has manure to compost and that sawdust will be used as a bulking agent. How much sawdust and water needs to be added to the manure to have a good compost mix?

Step 1. Determine the approximate nitrogen, carbon, moisture, and bulk density from Table 3 in Chapter 2.

Material	Nitrogen (dry weight) (%)	C:N (dry weight)	Moisture Content (%)	Bulk Density @ Moisture Content (kg/m³)
Broiler Breeder Manure	3.60	10	46	470
Sawdust	0.06 - 0.80	200 - 750	19 - 65	350 - 450

Note: For a range of numbers, take the average if there has been no analysis performed.

Sawdust	0.43	475	42	400

Step 2. Using the formula for two ingredients from Table 3, determine the amount of sawdust (a) needed for each kg of manure, (b) to give a desired C:N ratio (R) of 30.

Given:

b = 1 kg of broiler breeder manure
Ma = 0.20 (20% moisture content of sawdust)
Mb = 0.46 (46% moisture content of manure)
Ra = 500 (C:N ratio of sawdust)
Rb = 10 (C:N ratio of manure)
%Na = 0.1 (% nitrogen in sawdust)
%Nb = 3.6 (% nitrogen in manure)

Determine: a (weight of sawdust needed) for the desired C:N ratio of R = 30 (Appendix A_2)

$$a = \frac{\%Nb}{\%Na} \times \frac{(R-Rb)}{(Ra-R)} \times \frac{(1-Mb)}{(1-Ma)}$$

Calculation:

$$a = \frac{3.6}{0.1} \times \frac{(30-10)}{(500-30)} \times \frac{(1-0.46)}{(1-0.20)} = 1.0$$

Answer: For each kg of manure, add 1.0 kg of sawdust to obtain a C:N ratio of 30.

Step 3. Check the mix moisture content (M.C.) using the moisture content formula in Appendix A_2.

Given:

a = 1.0 kg weight of sawdust from Step 2
b = 1.0 kg weight of manure
Ma = 0.20 (20% moisture content of sawdust)
Mb = 0.46 (46% moisture content of manure)

Determine: M.C. (mix moisture content) (Appendix A_2)

$$M.C. = \frac{(a \times Ma) + (b \times Mb)}{a + b}$$

Calculation: $M.C. = \frac{(1 \times 0.20) + (1 \times 0.46)}{1 + 1} = 0.33$ or 33 %

Answer: This starting moisture content of 33% is too low, since ideal moisture content runs from 50 to 60%.

Step 4. Adjust moisture content to 55% using the two ingredient formula from Appendix A_2.

Given:
b = 1 kg of manure/sawdust mix
M = 0.55 (55% desired moisture content)
Ma = 1.0 (100% moisture content of water)
Mb = 0.33 (33% moisture content of manure/sawdust mix)

Determine: 'a' quantity of water required

$$a = \frac{Mb - M}{M - Ma}$$

Calculation: $a = \frac{0.33 - 0.55}{0.55 - 1.00} = 0.49$

Answer: Add 0.49 kg of water for every 1.0 kg of manure/sawdust mix.

Step 5. Determine how much manure, sawdust and water to mix.

Given:
Tractor bucket volume = 2.0 m^3
Manure bulk density = 470 kg/m^3
Sawdust bulk density = 350 kg/m^3

Determine: Volume of manure, sawdust, and water

Calculation: One bucket of manure weighs 2.0 m^3 x 470 kg/m^3 = 940 kg

Since an equal weight of manure and sawdust is wanted, add 940 kg of sawdust or 940 kg / 350 kg/m^3 = 2.7 m^3 of sawdust

This is equal to 2.7 m^3 / 2.0 m^3 per bucket = 1.35 buckets of sawdust

For each bucket of manure used, there will be a total manure/sawdust mix weighing 940 kg + 940 kg = 1840 kg

Similarly, for each bucket of manure used, add:
0.49 kg of manure / kg of mix x 1840 kg = 902 kg of water (902 L of water)

Answer: For each bucket of manure, add 1.35 buckets of sawdust and 902 litres of water.

Worksheet

Step 1. Determine the approximate nitrogen, carbon, moisture, and bulk density from Table 3 in Chapter 2.

Material	Nitrogen (dry weight) (%)	C:N (dry weight)	Moisture Content (%)	Bulk Density @ Moisture Content (kg/m^3)

Note: For a range of numbers, take the average if there has been no analysis performed.

Step 2. Using the formula for two ingredients from Table 3, determine the amount of sawdust (a) needed for each kg of manure, (b) to give a desired C:N ratio (R) of 30.

Given:

b = _____ kg of broiler breeder manure
Ma = _____ % (moisture content of sawdust)
Mb = _____ % (moisture content of manure)
Ra = _____ (C:N ratio of sawdust)
Rb = _____ (C:N ratio of manure)
%Na = _____ (% nitrogen in sawdust)
%Nb = _____ (% nitrogen in manure)

Determine:

a (weight of sawdust needed) for the desired C:N ratio of R = 30

$$a = \frac{\%Nb}{\%Na} \times \frac{(R-Rb)}{(Ra-R)} \times \frac{(1-Mb)}{(1-Ma)}$$

Calculation: a = _____ x _____ x _____ = _____%

Step 3. Check the mix moisture content (M.C.) using the moisture content formula in Appendix A_2.

Given:

a = _____ kg weight of sawdust from Step 2
b = _____ kg weight of manure
Ma = _____ % (moisture content of sawdust)
Mb = _____ % (moisture content of manure)

Determine:

M.C. (mix moisture content)

$$M.C. = \frac{(a \times Ma) + (b \times Mb)}{a + b}$$

Calculation: M.C. = _____ + _____ / _____ = _____%

Step 4. Adjust moisture content to 55% using the two ingredient formula from Appendix A_2.

Given:
b = _____ kg of manure/sawdust mix
M = _____ % (desired moisture content)
Ma = _____ % (moisture content of water)
Mb = _____ % (moisture content of manure/sawdust mix)

Determine: 'a' quantity of water required

$$a = \frac{Mb - M}{M - Ma}$$

Calculation: a = _____ L

Step 5. Determine how much manure, sawdust and water to mix.

Given:
Tractor bucket volume = _____ m^3
Manure bulk density = _____ kg/m^3
Sawdust bulk density = _____ kg/m^3

Determine: Volume of manure, sawdust, and water

Calculation: One bucket of manure weighs _____ kg

Since an equal weight of manure and sawdust is wanted, add _____ kg of sawdust or _____ kg / _____ kg/m^3 = _____ m^3 of sawdust

This is equal to _____ m^3 / _____ m^3 per bucket = _____ buckets of sawdust.

For each bucket full of manure used, there will be a total manure/sawdust mix weighing _____ kg + _____ kg = _____ kg

Similarly, for each bucket of manure used, add:
_____ kg of manure / kg of mix x _____ kg = _____ kg water
(_____ L of water)

These calculations can be done automatically by using the AAFRD manure composting calculator. The link for this calculator is:

http://www.agric.gov.ab.ca/app19/calc/manure/manure.jsp